National Aeronautics and Space Administration

The Fiber Nuller : Detecting faint companions close to bright stars

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Project Objectives

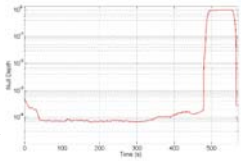
- Demonstrator for **TPF-I** : First ground-based **rotating nulling interferometer.**
- Coronagraphy : Very low **inner working angle** coronagraphic system.
- Science : Detection of **faint off-axis companions** (from binary stars to brown dwarfs).

Recent Results

Experiment	λ range [nm]	Best of Fiber Nuller nulls
Lab	632.8	~ 770,000 : 1
Lab	[1500;1800]	> 10,000 : 1
Palomar AO lab *	[2000;2400]	~100 : 1

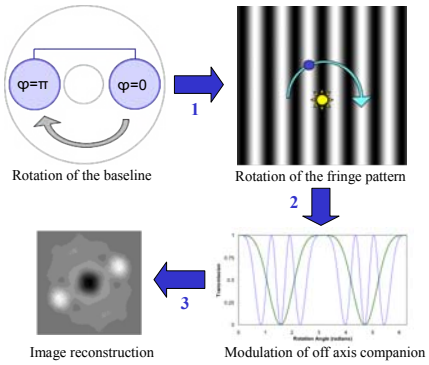
* Results obtained with the deployable fiber nuller mounted directly under the adaptive optics system of the 200" Hale telescope in the Palomar AO lab.

[1500;1800] nm null ⟶



Project Description

Principles

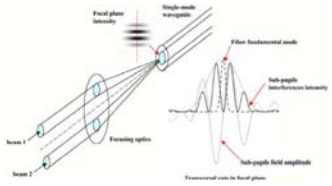


1. The rotation of the baseline induce a rotation of the fringe pattern with respect to the off-axis companion.
2. This rotation of the fringe pattern induce a modulation of the off-axis object.
3. Using cross-correlation technique, we can reconstruct an image.

The fiber nuller will be the first experiment to demonstrate this technique.

Current status

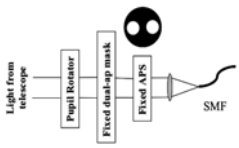
- **Deployable bench operational**
- **Improvement of the beams intensity balance as well as the background noise (chopping wheel)**
- **Throughput optimization**
  - o Comparison of ≠ single-mode fibers throughput
  - o Optimization of the fiber nuller layout
- **Optimization of the injection into the single-mode fiber**



- **Implementation of the pupil-rotator**

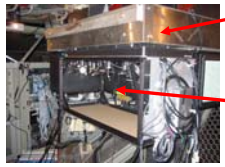
Pupil rotator (K-mirror)

Layout of the rotating nuller

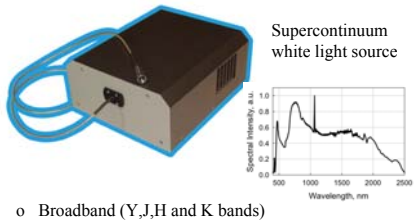


Future

- **Next engineering time in July 2008**
  - o Alignment of the nuller
  - o First nulling observation with a rotating baseline



- **Possible upgrade of our experiment**



  - o Broadband (Y,J,H and K bands)
  - o More flux (>10^3) so we can measure deeper nulls
  - o The source can be re-used for other high-contrast experiments

Benefits to NASA and JPL

- The Fiber Nuller will be the first nuller to demonstrate the rotating baseline-nuller concept envisioned for TPF-I (NASA) and DARWIN (ESA).
- First off-axis source detection and signal extraction with a rotating nulling interferometer (major step forward for TPF-I).
- First demonstration on a ground-based telescope of the fiber nuller method for beam combination.
- As a single-aperture telescope nuller and because of its very small inner working angle, this coronagraphic nuller is also of interest for coronagraphic missions such as TPF-C, Eclipse and other potential MIDEX proposals, such as GIMLI.

Publications

1. "Deep Nulling of Laser Light with a Single-Mode Fiber Beam Combiner," Haguenauer, P. & Serabyn, E. 2006, Appl. Opt., 45, 2749.

2. "Accessing Small Inner Working Angles with a Rotating Subaperture Nuller," Serabyn, E. & Mennesson, B. 2006, in Proc. IAU Coll. 200, "Direct Imaging of Exoplanets: Science and Techniques," eds. C. Aime & F. Vakili, p. 379.

3. "Testing the TPF Interferometry approach before launch," Serabyn, E. & Mennesson, B. 2006, in 2006 IEEE Aerospace Conference Proceedings, Big Sky, MT, March 4-11, 2006, paper 6.09.02.

4. "Deep broad-band infrared nulling using a single-mode fiber beam combiner and baseline rotation," B. Mennesson, P. Haguenauer, E. Serabyn and K. Liewer 2006, in Proc. SPIE 6268, 626830